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MIGRATION OF CILIATE IN THE WATER-UNSATURATED SAND

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Tan-Chi Huang (1984) Migration of ciliate in the water-unsaturated sand. *Bull. Inst. Zool., Academia Sinica* **23**(1): 127-130. *Tetrahymena pyriformis* could actively migrate inside the water-unsaturated sand, even when the water-content of the sand was only 34% of saturation. When the ciliate was embedded in soft agar where it could not move by swimming, it moved by squeezing within the agar. The shape of body changed drastically during squeezing so that it looked like an amoeba. Though it did not swim in the agar, its cilia were still retained, and when entered water the cilia reverted to the normal form immediately. This suggested that in the sediment or the wetted sand, the ciliate could migrate in a way similar to the amoebae.

Accumulated data indicate that protozoa play an important role in controlling bacterial population, including in the aquatic and in the soil environments (Danso *et al.*, 1975; Fenchel and Harrison, 1975; Johannes, 1965). Ciliate swimming is due to the beating of cilia, an efficient way of movement in aquatic environment. But in soil, movement by cilia may not be an efficient method of locomotion. Particularly when the soil is not in water-saturated condition, to move by swimming or by beating of cilia may be difficult. However, ciliates such as *Paramecia* has been shown to play a significant role on controlling the population of *Rhizobium* in soil (Habte and Alexander, 1977). This suggests that ciliates must be able to migrate in soil actively, otherwise such predation will be difficult. In this paper, migration activity of *Tetrahymena pyriformis* in water-unsaturated sand was examined and a possible movement mechanism different from swimming was suggested.

MATERIALS AND METHODS

Sources of microorganisms

An axenic culture of *Tetrahymena pyriformis* was obtained from Dr. T. P. Bruns, Cornell University, and maintained in proteose-yeast medium (PY) containing 2.0% proteose, 0.1% yeast extract, and 0.003% sequestrene (Geigy, Ardsley, N. Y.) in distilled water at pH 7.0. *Enterobacter aerogenes* was isolated in this laboratory, and grown in nutrient both containing 0.5% peptone and 0.2% yeast extract.

Preparation of the sand-containing column

The column was prepared by stacking glass rings together. Each glass ring is 19 mm in internal diameter and 10 mm in length. Six rings were fitted together and then wrapped outside with a plastic tape to form a column of 6 cm long. Sand was from river sediment, washed to remove as much clay as possible, then dried and passed through a 20 mesh sieve. This sand had a water holding capacity of 29.7 ml per 100 g, Both the sand and the

column were sterilized by autoclaving and re-dried, supplemented with sterilized water to the desired water content, then packed into the column, which was standing on a glass plate. During packing, sand was added slowly, and gently shaken until the column was completely filled with the sand.

Migration of protozoa in the sand

One ml of the protozoan culture (about 10^6 cells/ml) was mixed with 4 ml of the melted soft water agar (0.75%) and poured in a small petri dish (4.7 cm in diameter). After harding, an agar block (0.8 cm in diameter) was taken and inserted on the bottom end of the column. Several columns prepared by the same procedures were then kept vertically inside a beaker containing a piece of water-saturated cotton to maintain humidity. The mouth of the beaker was closed with a plastic cloth and then incubated at 26°C. On days 2, 4, and 6; one column was removed for assay of cell distribution in the column. The column was divided into six equal parts at the joints between the glass rings. The sand in each ring was separately put in a culture tube containing 2 ml of bacterial suspension (*Enterobacter*, 10^8/ml) and incubated at 26°C without shaking. After 4 days of incubation, each tube was examined microscopically for *Tetrahymena*.

Observation of the movement of protozoa inside soft agar

Point one ml of the protozoan culture (about 10^6/ml) was mixed with 2 ml of melted soft PY agar and evenly mixed. The mixture was immediately spread on a sterilized slide. The slide then kept within a sterilized petri dish and incubated at 25°C. After 16 hours of incubation, the culture was examined under phase contrast microscope and the movement of the protozoa inside the agar was photographed.

RESULTS AND DISCUSSION

Tetrahymena pyriformis migrated inside the water-unsaturated sand. When protozoa were put on the bottom end of the column packed with 70% water-saturated sand, they appared 2 cm away from the original site after 2 days of incubation (Fig. 1). This distance increased with further incubation. Migration speed was affected by the water content of the sand. But even with 34% saturation, the protozoa still had about 50% of the migration speed compared to 70% water-saturation. Since the ciliates migrated randomly, they must be very active in order to have significant migration speed. Fig. 1 also showed that migration speed slowed gradually during the incubation period, possibly due to starvation of the protozoa. If suitable prey were present migration might be enhanced.

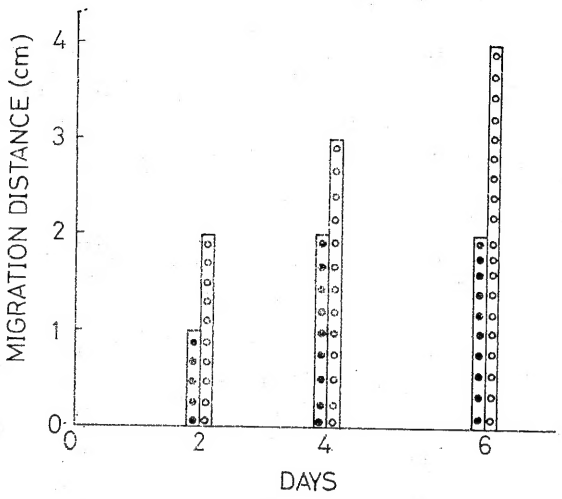

Fig. 1. Migration of *Tetrahymena pyriformis* in water-unsaturated sand. Closed circles (|●●●|) indicate the sand containing 34% water-saturation; the open circles (|○○○|) representing 70% saturation.

Many ciliates have the ability to squeeze through apertures smaller than their body size in the aquatic environment. However, the change of shape was thought to be limited. *Tetrahymena pyriformis*, embedded in soft agar where they could not move by swimming, changed their shape actively. Body shape changed so drastically during squeezing that it looked like an amoeba (Fig. 2). The morphology changed

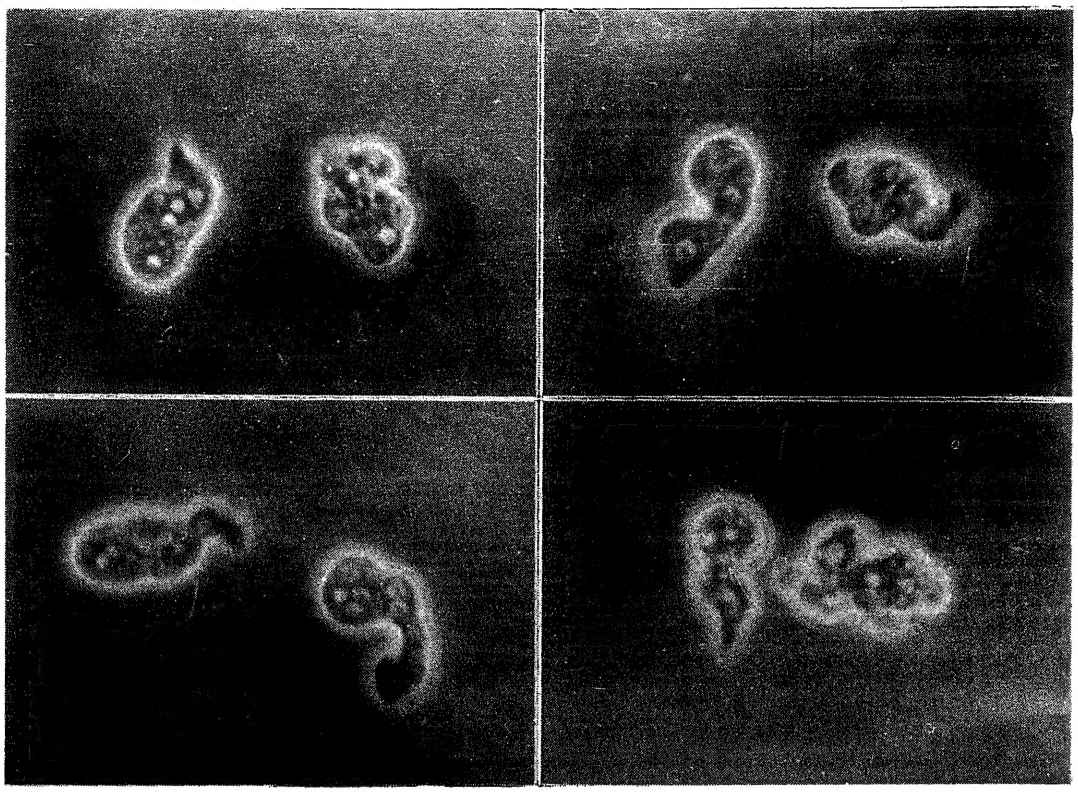

Fig. 2. Phase constrast microphotographs of *Tetrahymena pyriformis* in 0.75% agar. These four pictures were taken at different time to show the changing of their morphology. They were actively moving when pictures were taken. ×510.

very rapidly, and did not have a defined shape. However, the anterior could be distinguished from other parts, being usually wedge-shaped with less vacuoles. When moving through the agar, the whole body was led by the anterior. The organism grew and divided in the agar. Although it did not swim, its cilia were retained. On entering water, it reverted to the normal form immediately. This observation suggested that in sediment or wetted soil, the ciliate could migrate in a way similar to amoebae.

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纖毛蟲在水分不飽和沙中的移動

黃 檀 溪

四膜蟲（*Tetrahymena*）於含水量不飽和的沙中，甚至於含水量只達 34% 飽和度時，均能活躍地移動。如將四膜蟲埋於瓊脂培養基而使其無法游動時，他能以鑽動方式運動；此時其形態變化極大而呈變形蟲狀，但其纖毛仍然存在，於進入水中後能立刻恢復原來形狀。根據以上觀察，纖毛蟲在沉積層或潮濕沙中可能以類似變形蟲之運動方式進行移動。